HCA Groene Waterstof
2024-2026

Digital Twin Driven Approach for Asset Management of Emerging Green Hydrogen Facilities

Sondos Saad,
Vana Tsimopaoulo,
Padraig Naughton

12/2/2025

Medegefinancierd door de Europese Unie

JTF Fonds voor rechtvaardige transitie

UNIVERSITY OF APPLIED SCIENCES

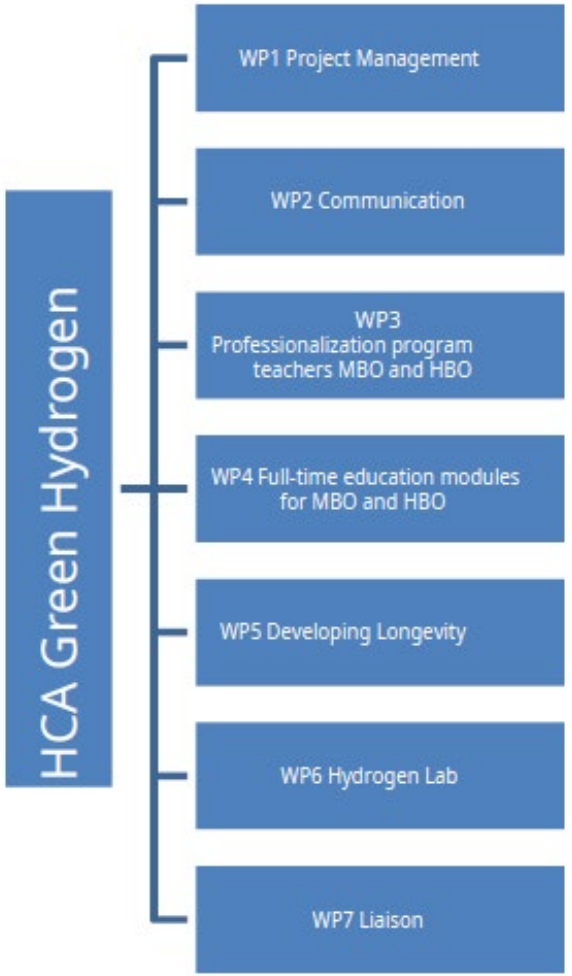
Outline

- **Motivation**
- Stakeholders Interest
- Research Question
- Work Flow
- Expected outcomes

UNIVERSITY OF APPLIED SCIENCES

HCA Green Hydrogen Project

- NL reserved budget to participate in European IPCEI project initiatives
- For hydrogen, €35 million is available for wave 1, €783.5 million for wave 2, €600 million for wave 3 and an expected 200 million for wave 4
- EU Just Transition Fund supports regions most affected by transition to climate neutrality, by enabling people adapt to a changing labour market.
- JTF HCA project (1-1-2024 to 31-12-2026) aims to develop a full educational and training program to have professionals ready in Zeeland in 2026, when the first green hydrogen facilities in Zeeland become operational.



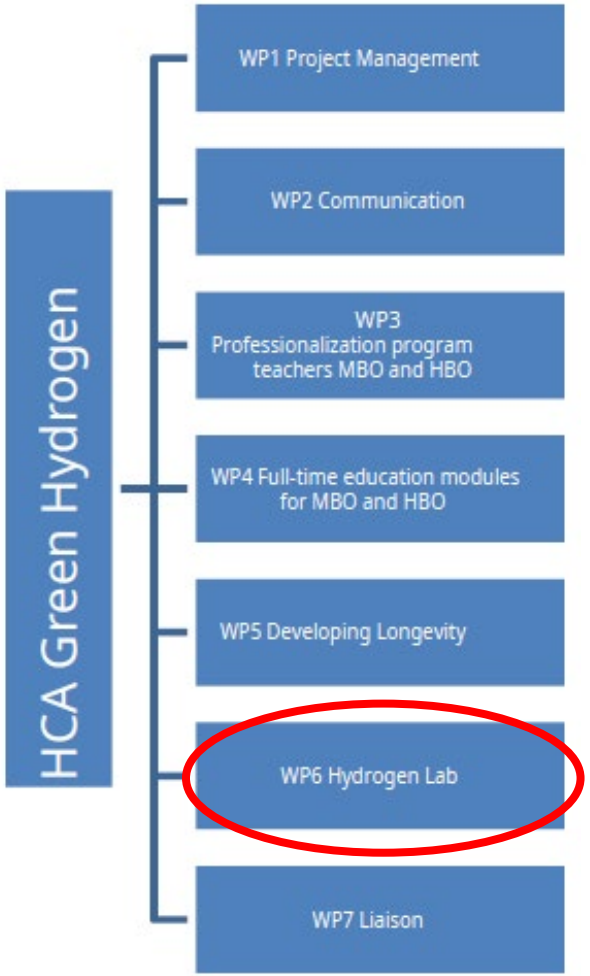
UNIVERSITY OF APPLIED SCIENCES

WP6- HCA Green Hydrogen Project

Old ways of working disappear !

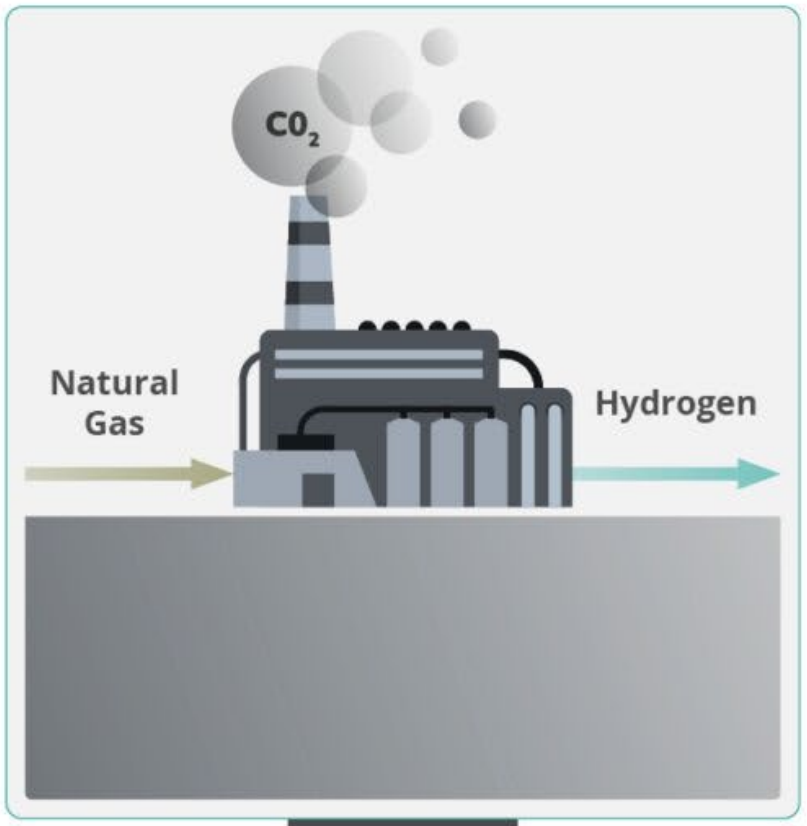
- New technology: Steam methane reforming → emerging (electrolysis)
- Big Data and Digitalization
- Asset Management takes O&M into account in design phase
- Need for practical education and research for students

Hydrogen Lab → Digital Lab → Digital Twin



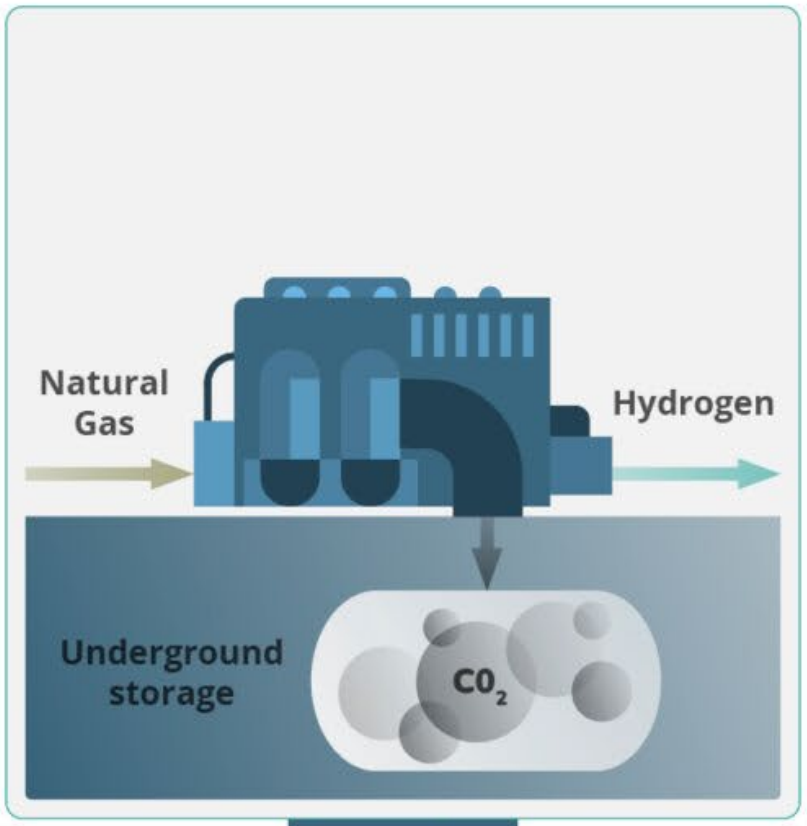
UNIVERSITY OF APPLIED SCIENCES

GREY HYDROGEN



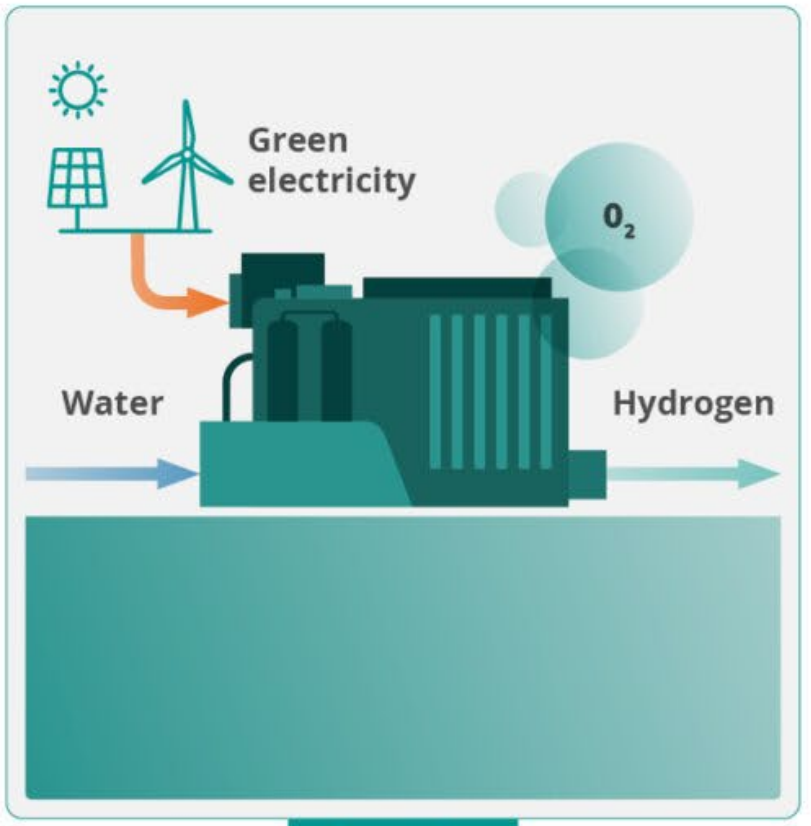
Higher carbon

BLUE HYDROGEN



Lower carbon

GREEN HYDROGEN



Zero carbon

GREEN HYDROGEN MARKET (Global)

By Technology Segment

- Alkaline Electrolyzer
- Proton Exchange Membrane
- Solid Oxide Electrolyzer

Market Value in 2020
USD 755 Million

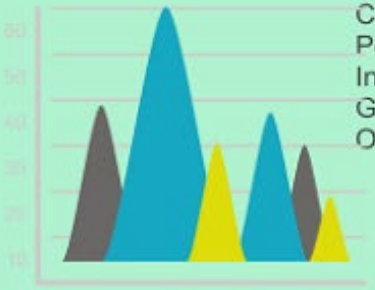
By Region

Market Value in 2026
USD 1,423.2 Million

Key Market Players

- Linde
- Air Liquide
- Air Products and Chemicals Inc.,
- Uniper SE
- Siemens
- Green Hydrogen
- Hydrogenics
- Others

By Application

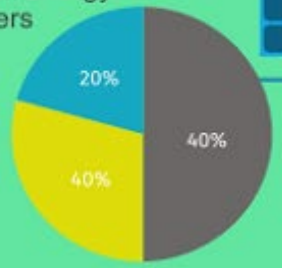


- Mobility
- Chemical
- Power
- Industrial
- Grid Injection
- Others

2021-2026 CAGR 13.8%

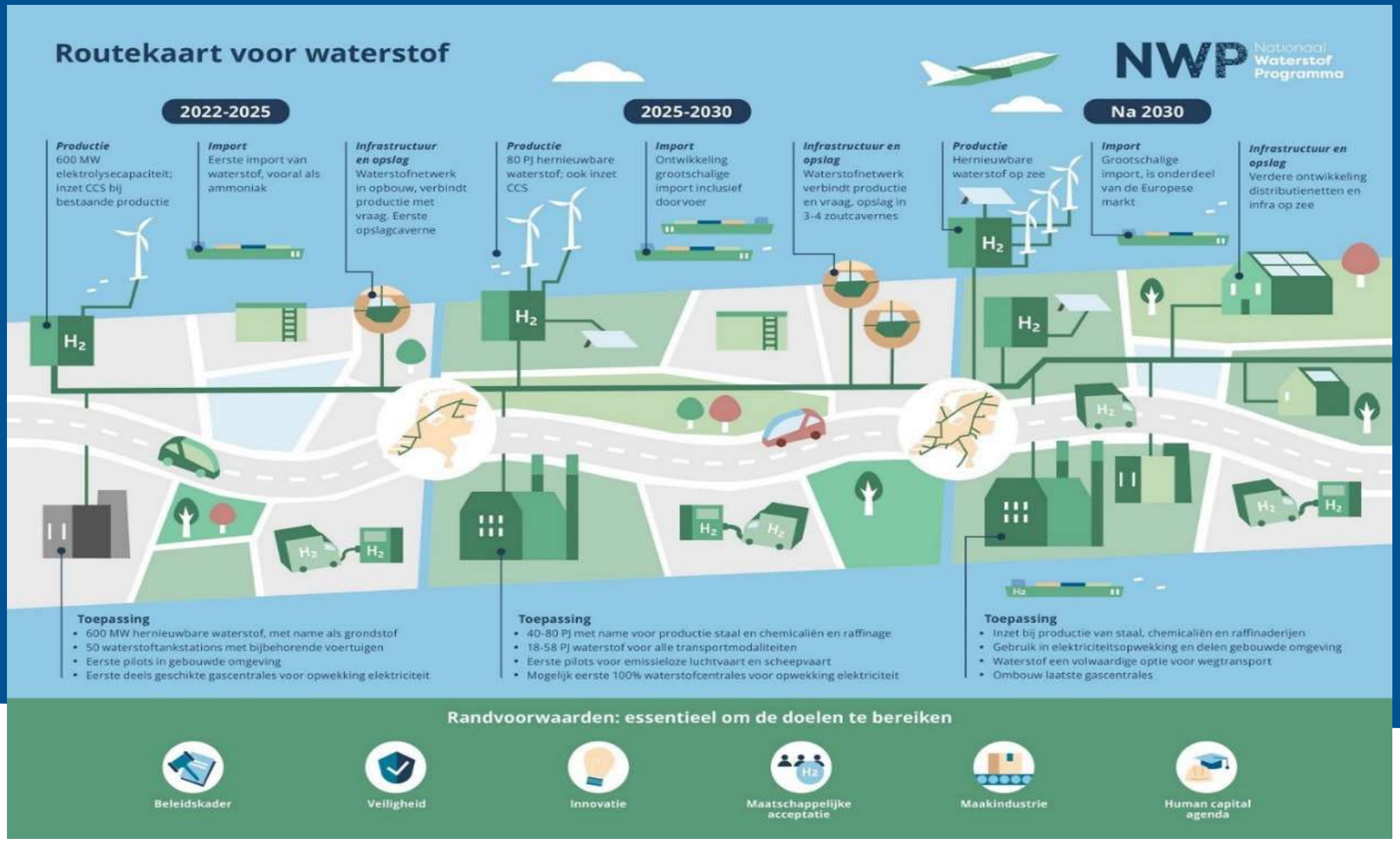
By Source Segment

- Wind Energy
- Solar Energy
- Others



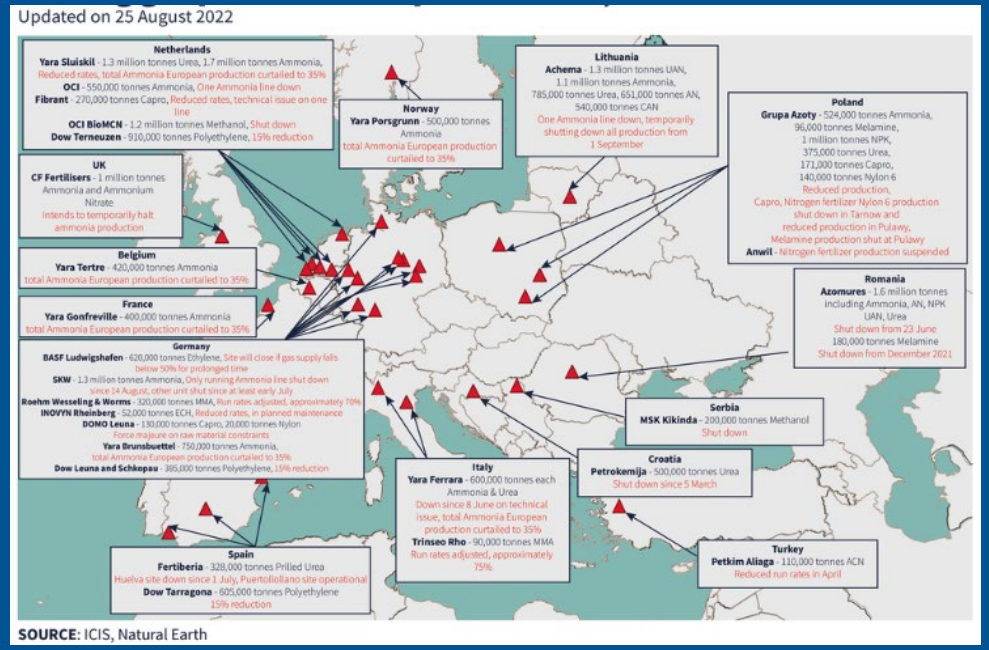
Facts Factors | Source: Facts & Factors Research |

The Hydrogen Transition in NL-Zeeland

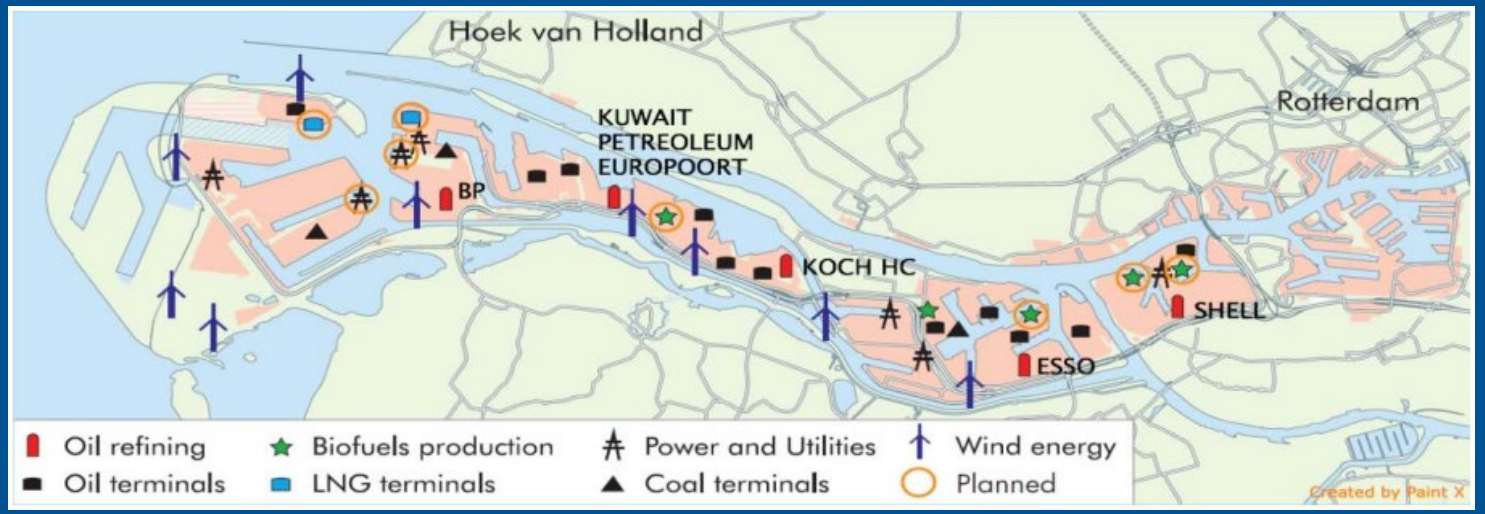


Clusters of chemical industries in the Netherlands

TARGET MARKET



SOURCE: ICIS, Natural Earth



UNIVERSITY OF APPLIED SCIENCES

GREEN HYDROGEN PRODUCTION

by CIC energiGUNE

MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

RENEWABLE ELECTRICITY

WIND SOLAR GEOTHERMAL

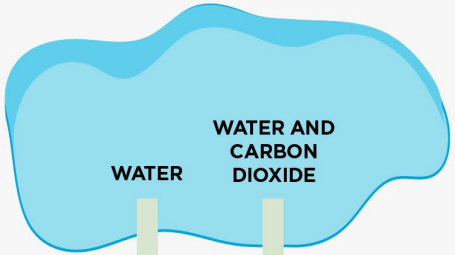
ELECTRIC GRID

ELECTRIC VEHICLES

DOMESTIC HEATING

HEAT PUMPS

CONVENTIONAL USE



WATER WATER AND CARBON DIOXIDE

ELECTROLYSIS

GREEN HYDROGEN

GREEN HYDROGEN

CHEMICAL INDUSTRY

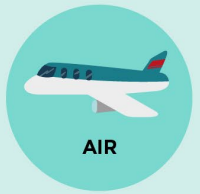
CHEMICALS

FERTILISER AND CHEMICALS

FUEL SYNTHESIS

FUELS

HEAVY TRANSPORT

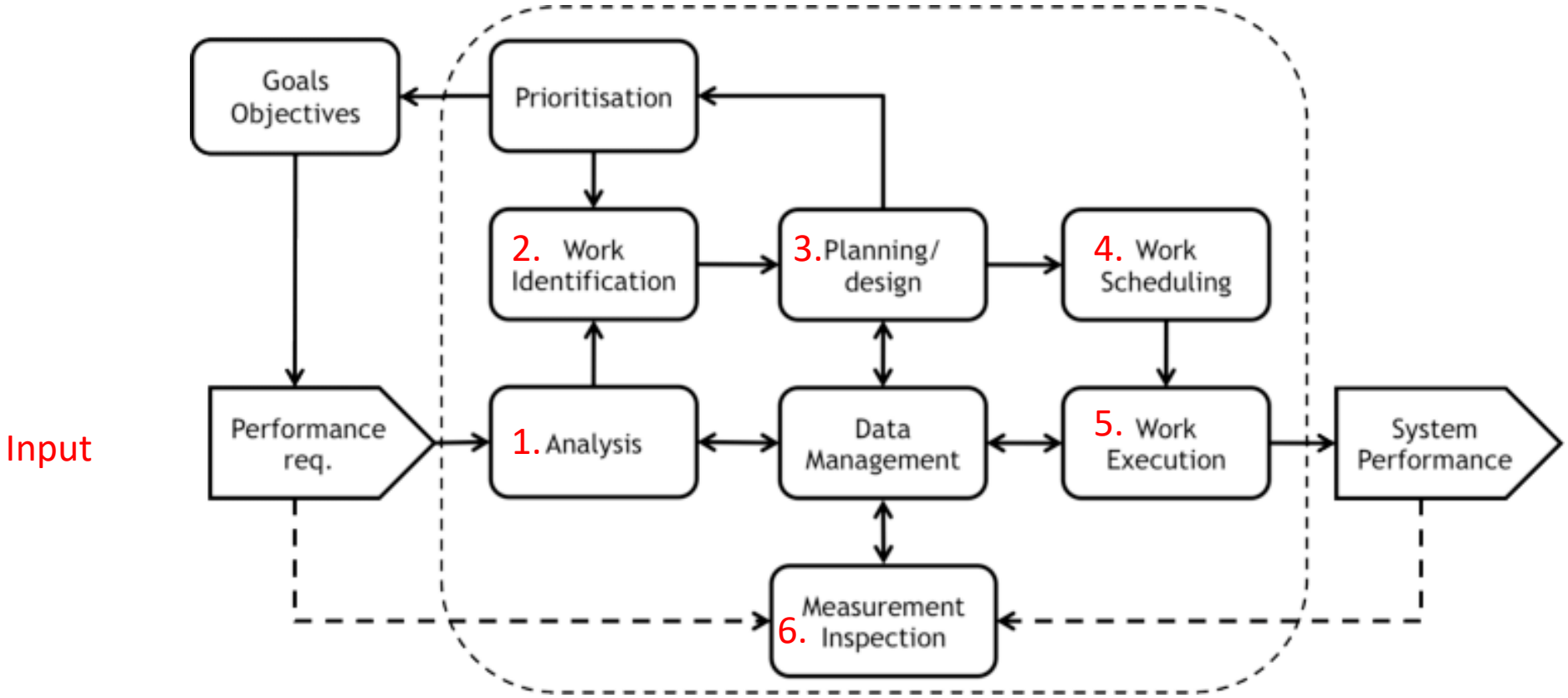


AIR

SEA

LAND

Six-Stage Model for Asset Management (AM)

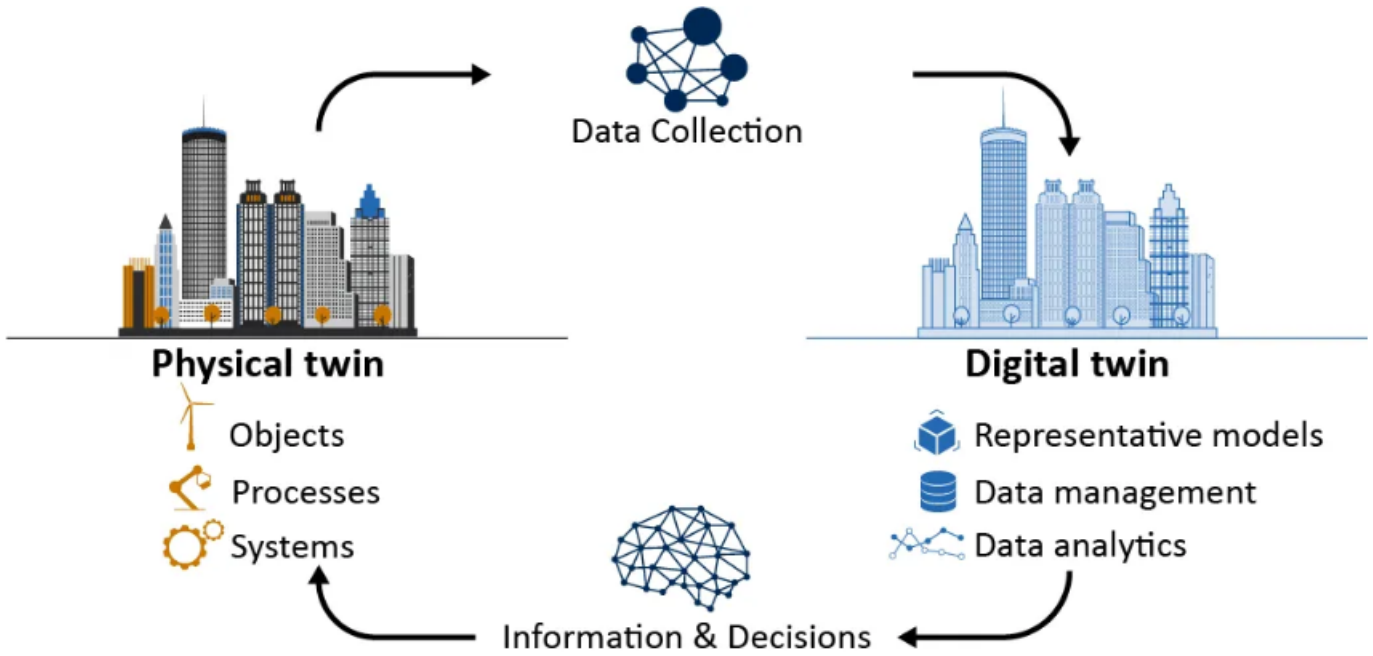


UNIVERSITY OF APPLIED SCIENCES

Source: Schoenmaker, R., & Verlaan, J. (2013). Analysing outsourcing policies in an asset management context: A six-stage model.

Digital Twin

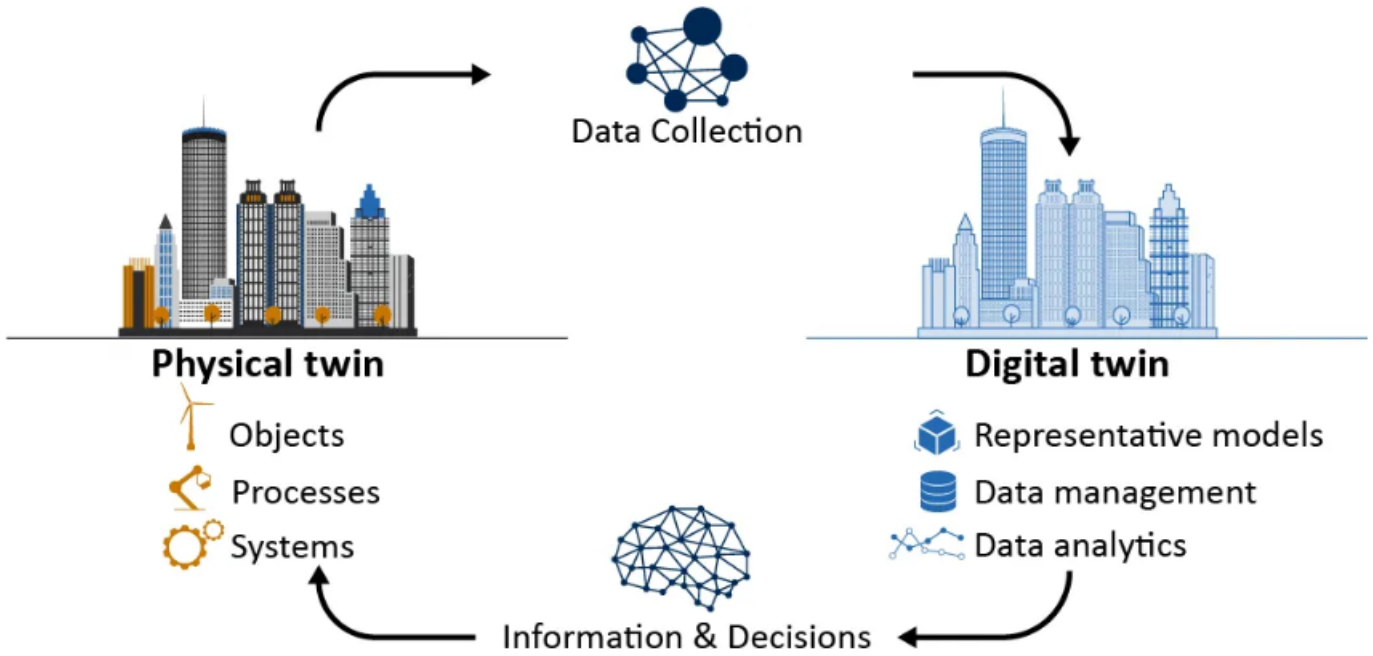
A digital twin is a digital model of an intended or actual real-world physical product, system, or process that serves as a digital counterpart of it for purposes such as simulation, integration, testing, monitoring, maintenance and optimization.



Source: https://www.gao.gov/products/gao-23-106453

Digital Twin for AM

- DT is the core of the data management in 6-stage model
- Students need to develop to control the process
- Start with simplified DT (Global to Refined approach)
- Further developed by students
- Further validated in real life case study



Source: https://www.gao.gov/products/gao-23-106453

UNIVERSITY OF APPLIED SCIENCES

Outline

- Motivation
- **Stakeholders Interest**
- Research Question
- Work Flow
- Expected outcomes

UNIVERSITY OF APPLIED SCIENCES

End User

1. Suitable form as fuel (liquid/gas)
2. Competitive Prices

Asset Owner

1. Min CAPEX & OPEX
2. Max system availability

HZ

1. Need for academic research
2. Applied research & education
3. Collaboration

HZ UNIVERSITY OF APPLIED SCIENCES

Outline

- Motivation
- Stakeholders Interest
- **Research Question**
- Work Flow
- Expected outcomes

UNIVERSITY OF APPLIED SCIENCES

Green hydrogen plays an increasingly important role in meeting decarbonization and energy transition targets. ***How can modeling capabilities help accurately simulate, analyze and optimize processes for hydrogen projects to meet design targets and optimize performance?***

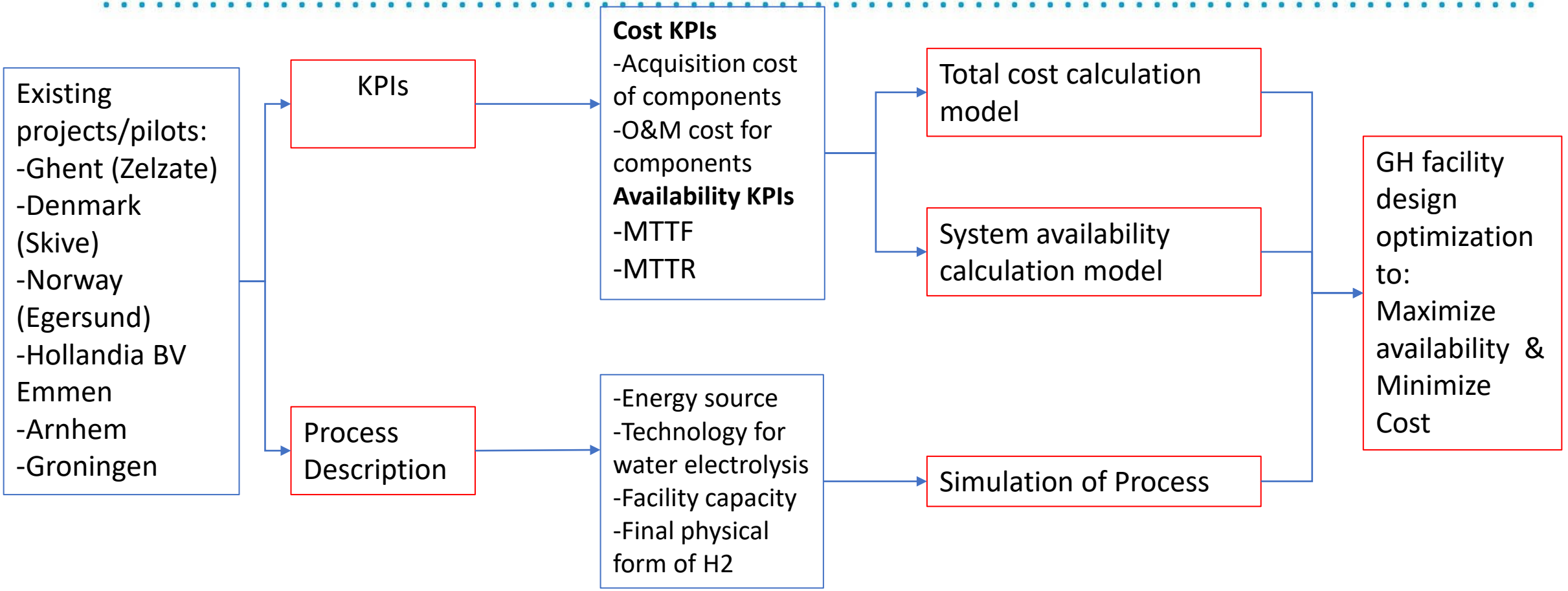
UNIVERSITY OF APPLIED SCIENCES

Outline

- Motivation
- Stakeholders Interest
- Research Question
- **Work Flow**
- Expected outcomes

UNIVERSITY OF APPLIED SCIENCES

Work Flow



UNIVERSITY OF APPLIED SCIENCES

Outline

- Motivation
- Stakeholders Interest
- Research Question
- Work Flow
- **Expected Outcomes**

Expected Outcomes

- Develop a hydrogen educational setup for practical education
- Accelerate hydrogen projects with rigorous validated models that match real-world performance
- Increase TRL by analyzing techno-economic feasibility of design alternatives
- Reduce dependence on expensive testing facilities
- Leverage innovative process designs to reduce risk and decrease cost using AM approach and generating feedback loops

UNIVERSITY OF APPLIED SCIENCES

Bedankt!

UNIVERSITY OF APPLIED SCIENCES

De persoonlijke hogeschool